

Electrophoretic Deposition of Particulate Zirconia Films on Porous Ceramic Cathodes for Use in Solid Oxide Fuel Cells

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Recently, a major worldwide research effort has arisen in an attempt to create an economically viable simple fabrication process for producing impervious ZrO_2 -8mol% Y_2O_3 (8YSZ) electrolyte films (40-50 μm thickness) on porous air electrode supported (AES) doped- LaMnO_3 cathode tubes for use in high temperature tubular solid oxide fuel cells (SOFCs). To date, electrochemical vapor deposition (EVD) has been used extensively to fabricate superior quality 8YSZ films (1), but due to the high associated cost, several non-EVD approaches are also being attempted (2-4).

Electrophoretic deposition (EPD) is one of the inexpensive and simple processing techniques, which can be employed to fabricate high quality zirconia films directly on the porous tubes (5). In EPD, charged particulates from a stable suspension move towards and deposit on an oppositely charged counter-electrode under an applied electric field. For SOFCs, the counter-electrode is the doped LaMnO_3 , and its porous nature gives rise to a locally inhomogeneous electric field which proves to be a challenge for depositing homogeneous 8YSZ films by EPD. In the present work, a fugitive graphite phase is used as an interlayer on the porous doped- LaMnO_3 tubes prior to EPD, thereby homogenizing the electric field and allow a homogeneous densely packed ($\sim 60\%$) film to be achieved in a single deposition step (Fig. 1). While firing, it was found that initially (at 1250 $^\circ\text{C}/2\text{h}$), the sublimation of the graphite interlayer cause the films undergo a free-floating stage in which they sinter independently (unconstrained sintering) from the substrate. However, by 1350 $^\circ\text{C}/2\text{h}$, the films reattach to the substrate, without leaving residual graphite impurities at the substrate. Fig. 2 represents a typical pore-free surface morphology of a uniform 25 μm thick gas-tight film (Fig. 3) obtained by a single step EPD onto interlayer coated porous cathode tubes after firing at 1350 $^\circ\text{C}$.

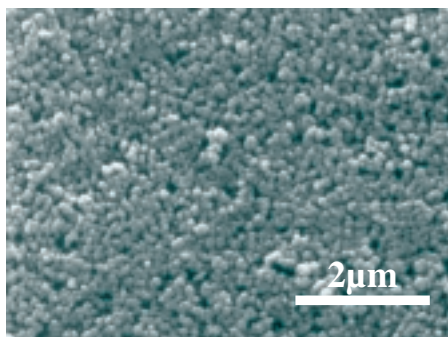


Fig. 1. Surface morphology of as-deposited 8YSZ EPD film (unfired) on AES porous LDM cathode tube coated with fugitive graphite interlayer.

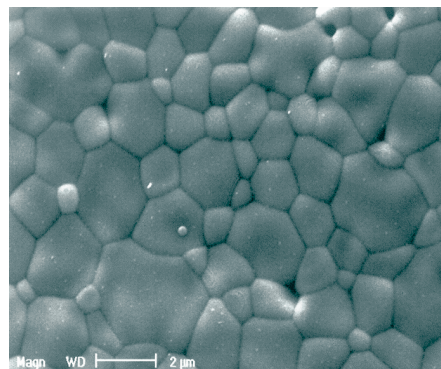


Fig. 2. Surface morphology of sintered (1350 $^\circ\text{C}$ for 2h) zirconia EPD film on AES porous LDM cathode tube coated with fugitive graphite prior to EPD.

Preliminary EDX results on the fugitive interlayer coated fired EPD zirconia films show no trace of La-diffusion from the substrate to the film even after firing at 1350°C/4h. On the other hand, La-diffusion was prominent for the films without interlayers. Hence the fugitive interlayer - EPD approach may have the ability to prevent formation of an unwanted $\text{La}_2\text{Zr}_2\text{O}_7$ insulating phase at the interface between the film and the substrate. Fig. 4 shows the high quality zirconia films (unfired, Fig. 4a and fired, Fig. 4b) obtained by a single step EPD on a graphite interlayer coated porous cathode tube. Detailed experiments on gas-tightness, electrical and micro-structural characterizations of these sintered films are underway.

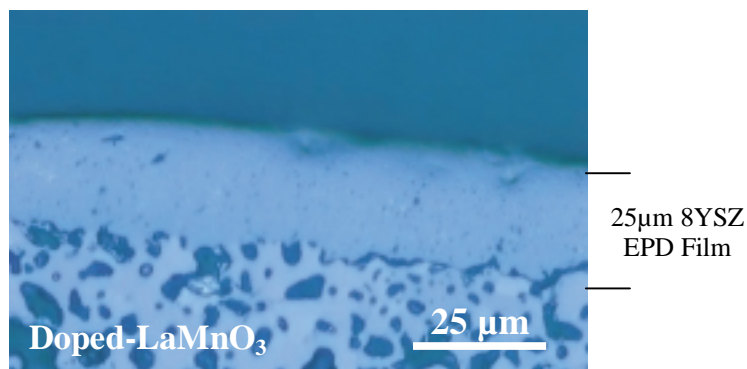


Fig. 3. Optical micrograph of sintered YSZ/doped-LaMnO₃ sample in cross-section. The cathode tube was coated with fugitive graphite prior to EPD.

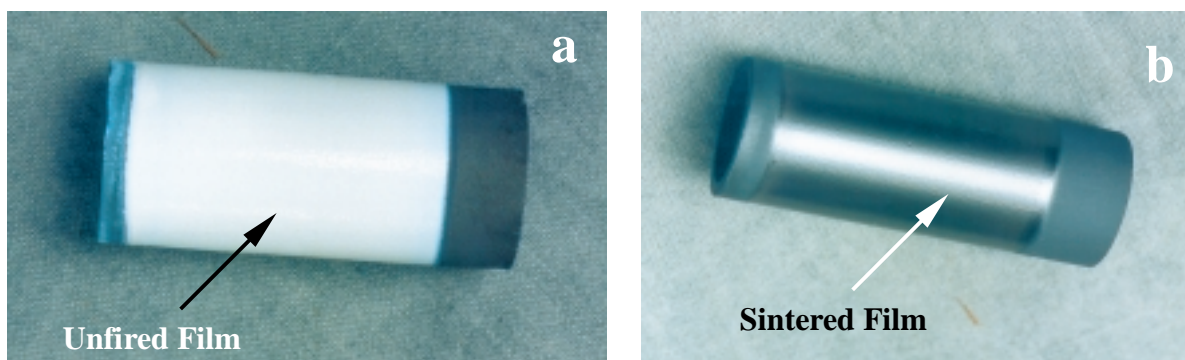


Fig. 4. Photographs showing 8YSZ films prepared by EPD on porous doped-LaMnO₃ cathode tubes : (a) Unfired (green) and (b) fired. Fired films appear glossy black because they are transparent to the black underlying substrate. In both the cases a fugitive graphite interlayer was used prior to EPD. Tube dimensions: length-2", dia-22mm and thickness-2mm.

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